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Criteria for Foreign Investment by an American Company *

By Joseph P. Berndt, Special Projects Manager
Development Department, Overseas Division
Monsanto Chemical Company

This apparently innocent title could conceivably touch off a series of debates in Congress, become a plank in a political party platform, stimulate some lengthy philosophical discussions or even create a riot in the legislative assembly of some foreign government. There is a great deal of emotion connected with this subject as well as concern, on the part of persons within government and business, about the effect foreign investment has on our balance of payments, our economic well-being, and even our foreign policy. Certainly the current administration's foreign policy and taxation programs will strongly influence new foreign investments in the future. These are subjects which are receiving considerable attention, as well they should.

It is certainly understandable why this subject, "Criteria for Foreign Investment by an American Company", was selected for the meeting of the Engineering Economy Division of the ASEE, because both Engineering and Economics play the key roles in any investment decision. However, I hope to outline for you how foreign-investment decisions require the consideration of many criteria, in addition to Engineering and Economics, which are not factors on the domestic scene. These others include International Politics, Finance and Law. Differences in methods of doing business, objectives of enterprise, as well as language and even units of weights and

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*From the writer's presentation at the Engineering Economy Division Conference, American Society for Engineering Education Annual Meeting, University of Kentucky, June 29, 1961.

measures, tend to add to the complexities.

The broadness of scope both challenges and frustrates those working in this area of foreign investment. In spite of a good deal of specialization in engineering, law, finance, taxes, etc., it is difficult to be sure that all factors have been adequately studied. Of course, timing is always important. Just as baseball is often referred to as a "game of inches", so putting an investment package together requires the right set of conditions, at the right time, to make the successful "play". Coordination of all these factors is the prime responsibility of the American companies' overseas managers.

Before proceeding, I would like to focus on the word "investment", as we understand it in a free-enterprise system. I like to define investment as a commitment of capital and manpower to an operation for generating profit, and I want to point out quickly that the fixed capital of the investment can only be "controlled" before it becomes machinery and buildings. Once the investment is made, its profit potential is virtually fixed. Furthermore, this fixed capital becomes the flywheel for the additional commitment of working capital and manpower. These points emphasize the necessity for careful evaluation of the criteria for investment.

As you probably have already noted, built into the definition of investment was the primary criterion for any investment decision -- profit; and a foreign investment, of course, can be no exception. All other criteria must be oriented towards profitability. I trust that this is an acceptable objective, but I am reminded of a "letter to the editor" in a recent issue of Industrial Research, whose writer was taking exception to an article in which the author stated that the "old cliché of profit being the prime objective of business enterprise is gradually disappearing". The writer of the letter commented that, in his part of the country, children are still allowed to say "profit" in front of grandparents, ministers and baby-sitters, and he hoped the day would

never come when the word need be spoken out behind the barn.

While it is true that the American company's first obligation is to its stockholder, there can be no doubt that the citizens of the host country reap far more benefits than does the American company. The investment provides additional goods and wages. It creates a demand, and also provides the training, for improved skills in the labor force. One investment normally creates another through the need for additional supplies and services; and this is a process which, after several cycles, broadens like the ripples on a pond, to a stronger economy. These businesses contribute to taxes, which in turn can be used for the general welfare of the country. This type of foreign-investment activity must certainly be an asset toward building good relations for our country, as well.

While profit must be the primary criterion for foreign investment by an American company, an intelligent appraisal of both long-term and short-range profits is required. It is not the objective of most reputable companies to exploit a local situation for undue amounts of profit. Most sound investment decisions are based upon being in business indefinitely. In any economy, unless the company has a product or a service which will contribute to the country's development and needs, it has little justification for existing, and probably will not last very long.

Now let's look at the profit motivations for a foreign investment by an American company. These are:

(1) Retention or expansion of markets built upon export sales.

(2) Increase in utilization of technological strengths.

(3) Provision of captive markets for Unites States products.

(4) Participation in promising economies.

(5) Availability of raw materials or other unique economic factors.

(6) Advantages of an opportunistic situation.

The first in this list of investment incentives abroad is to retain or expand markets built upon export sales. While an American company in some cases can make more short-term profit by shipping goods produced in the United States to the foreign countries, it often becomes necessary to produce locally, either because of trade barriers, the problems of offering effective customer or technical service, or the need to develop an adequate market for an economic-size plant. Sometimes the supply at home may be limited and it is more economic to build the required capacity abroad to free domestic capacity for use at home.

The trade blocs of the EEC (European Economic Community) and the EFTA (European Free Trade Area) have stimulated or brought about the need for having manufacturing facilities behind their tariff barriers. The long-range outlook is for more regional economic blocs, such as those in Latin America and Southeast Asia. While these are now in their embryonic stage, their effectiveness may still be over five years away.

The second investment motive is to increase the utilization of technological strengths of the American company. Foreign investment often offers a rapid extension in the use of the technology which a company possesses. For essentially no additional research or development, the same technology can be used in other important economies in the world. The technology may provide equity in an overseas investment, or royalty income. Monsanto has used its plastics technology (particularly polystyrene) in this manner for investments in the United Kingdom, Japan, Mexico, Argentina, Australia, Canada, France and Italy.

The third incentive is to provide captive markets for United States products used as raw materials or intermediate products by the overseas company. This approach provides the American company with outlets for its domestic products and offers profit from the end-product producing investment in the foreign country. For example, Monsanto supplies styrene monomer from Texas City to its company in Mexico which produces

Monsanto's Lustrex.

Number four is to participate in promising economies. In this case, the job becomes one of trying to find a product which is needed in this economy and which fits the technical or marketing strengths or special "know-how" of the United States company.

The fifth foreign investment incentive is based on the availability of raw materials and other unique economic factors. Oil, bauxite and other raw materials for the extractive industries are well known examples of this motivation. Low-cost labor may also be a factor, but rapid increases in overseas wage rates and somewhat lower efficiencies are making foreign labor less and less an incentive.

The sixth motive is to take advantage of an opportunistic situation. Occasionally the special situation arises where, because a company is active in the foreign field, opportunities occur which do not always fit the immediate objectives of the company but which can be taken advantage of for profit. In this case, the primary contribution of the American company is probably managerial experience and capital.

Investment opportunities can be found which offer the American company a controlling interest, a 50/50 ownership, and ownership of less than 50%. Monsanto Chemical Company is using all three types. The factors affecting the decision to use one of these three types varies considerably from country to country and from partner to partner. These factors will be elaborated upon later.

The types of investment also include expansion of the capacity of existing facilities in an overseas company, the addition of new-product facilities in an existing company, and the acquisition of companies. The most all-inclusive type of investment from a criteria viewpoint is the establishing of an entirely new company in a country where the American company does not have a manufacturing investment. Since this type of investment requires consideration of virtually all the criteria involved in a foreign investment, it will be the

one generally considered for the rest of this discussion.

"Criteria for Foreign Investment by an American Company" can be summarized into six general headings: Profit, Investment Climate, Financing and Corporate Structure, Technology, Marketing and Personnel. We have already discussed the Profit criterion at some length, so let us move on to the next major heading, that of Investment Climate, which includes the following:

Political Stability and Type of Government
Attitude Towards Foreign Investment
Economic Stability and Maturity
Tariffs and Duties
Labor Unions and Social Legislation
Taxes
Patent and Property Rights

The importance of political stability has been highlighted by our rather difficult neighbor, Cuba, where many millions of dollars of investment have been confiscated. Operating with a democratic free-enterprise form of government is certainly to be preferred over operating in socialistic countries where government is active in business; but opportunities can be found in almost any country except those dominated by Communism. Furthermore, the world is constantly changing, and this requires continuous appraisal of the risks of doing business overseas.

The attitudes of our government and the foreign government can do much to encourage or discourage investment around the world. The trend toward nationalism in many countries is limiting foreign investment by American companies.

The most important economic factor is probably the stability of the purchasing power of a country's currency. While we hear a great deal about inflation in this country today, compared with other countries around the world our inflation is quite small. For example, in a ten-year period

inflation has reduced the purchasing power of the currency in Brazil by 85% and in Argentina by 91%. Unless prices can keep pace with inflation, the profitability of a "dollar" investment in a foreign country can very quickly fall into the unprofitable or unacceptable level of return. The problem confronting the investor in the inflationary economy is whether to put in hard United States dollars which may lose their original value, or borrow in local currency and pay interest rates two, three or even four times those in the United States. Generally, some compromise is sought to hedge the two extremes, but the risk or financial burden persists.

Many countries, to stimulate local manufacturing and self-sufficiency, protect their local industries with substantial tariffs and duties. This protection offers a good incentive for local manufacture, but with it goes the constant threat that at some point these tariffs will be reduced, and care must be taken that at the lower tariff levels a project would still show good profitability. Just last year the Australian government virtually eliminated import restrictions, thereby putting severe competitive pressures on a number of locally-manufactured products.

Many foreign countries have labor unions as well as social legislation, which must be investigated prior to an investment decision overseas. In some countries, for example, it is almost impossible to remove people from the payroll, regardless of whether or not there is a need for them.

Taxes are a serious problem anywhere, and around the world one will find taxes on dividends, on royalties, on earnings, sales, etc. Obviously taxes are a cost of doing business, and affect profitability as much as raw materials and labor. In many cases, they are far more complex and difficult to predict, or even understand. Low taxes, particularly in the early years of a project, are often offered by the less developed countries, as an incentive for foreign capital investments. Of course, income returned to the United States is taxed at the 52% rate, less a credit for

taxes paid in the foreign country. When the United States company is trying to keep its total earnings, after all taxes, at acceptable levels for the United States stockholder, it is handicapped by the necessity for competing against other companies operating from countries with lower tax rates. Taxes, both foreign and domestic, have been recent headline news, but my comment is limited to pointing out their significance in arriving at an investment decision.

In most countries outside the Iron Curtain, patent law is practiced and technological achievements are recognized as property with its full rights. The degree to which patent laws are practiced and enforced will vary considerably, however, and these should be investigated thoroughly to ensure the availability of the protection and the incentives.

The third general criterion, that of Financing and Corporate Structure, plays a major role in foreign investment. Major factors are:

Income and Cash Flow
Sources of Capital
Working-Capital Requirements
Partners Available
Local Corporation Laws

Estimates of income and cash flow are not only essential for determining the profitability of a project, but also for establishing the kind of financing and the amount of outside capital which will be needed above and beyond that which can be generated internally. Capital may be available in the United States or locally, and may be invested as equity or loans. Both private and governmental sources of capital may be used. Even though the United States company may be able to finance the total project from its own treasury, it is generally desirable to obtain local funds as a hedge against inflation, as well as to identify the venture locally. Working-capital requirements, of course, are considered as a part

of cash flow, but they are highlighted here because often in foreign investments the working-capital requirement can be as large as the fixed capital. Over 100 days to pay bills is not unusual in some Latin-American countries. When money is short, the pressure for even longer terms builds up.

The use of partners in an overseas venture has many desirable aspects, particularly because they usually know their way around in dealing with government and financial agencies. Partners are also helpful in the marketing of products. Careful consideration must be made of the partners, as to their competence, integrity, and financial condition. On the other hand, the advantages in going it alone are full responsibility and authority, with no conflict-of-interest problems. In some countries, corporation laws often limit the ownership of a foreign company to a 50% interest, in which case a partner or a public stock issue would be required, as in Spain and Japan.

As stated previously, Technology and Engineering play a primary role in every investment decision. The following sub-topics have special meaning for a foreign project:

Process Familiarity
Process Complexity
Raw Material Availability
Equipment Supply
Research and Development Support
Patent Considerations
Plant-Site Factors

For the most part, the technology used overseas will be familiar to the investing company. However, when this is not the case, additional precautions and study are required. The process complexity should not be beyond the capabilities of the United States company to provide both technical support and competent personnel at the operation.

In some economies, much of the raw material must be

imported, and duties and restrictions require a different appraisal from that which is normal in the United States. Raw-material quality and grades may also require changes in process or end-product specifications.

In general, the research-and-development support will be provided by the United States parent, but in the more developed countries it is very often useful to have related research going on so that technology can be developed which offers another source of technical manpower to the United States company.

Patent laws, as previously mentioned, have a bearing on the investment climate, but the specific patent considerations are more closely related to technology. Care must be taken that, if patent protection is vital to the success of the project, the patent be valid. It would be disastrous to find, after the investment is made, that the process is infringing on a competitor's patent. The patent position can be more difficult to determine overseas than it is in the United States.

Plant-site considerations have been covered in numerous publications, which are useful overseas, but the availability of utilities and maintenance services in a foreign country (as compared with those in the United States) can be very limited. For example, drilling of wells for water is closely regulated around Mexico City. Waste disposal and air pollution, while not generally thought of as a problem in an underdeveloped country, must be taken just as seriously. Injury to a farm crop, animals, or local personnel could create considerable prejudice against an American firm. Quite often the local government will also be a strong influence in a plant-site location.

Just as engineering is vital to the technical success, Marketing is vital to the commercial success of a new venture. Most of the marketing considerations are identical to those in the United States, as will be noted from the following key points:

Product's Contribution to the Economy

Customers

Competition

Pricing

Channels of Distribution

Technical and Marketing Services Required

Credit Practices

Transportation Available

Packaging and Shipping

One major difficulty in forecasting sales overseas is obtaining meaningful statistics, to the same degree that we have them in this country. The misuse of statistics in foreign countries can be an even greater "booby trap" than domestically. Perhaps the safest measure of the market in another country is preselling the market through export sales from United States production.

As marketing maturity develops, more technical and marketing services will be required, and this condition should be provided for in both sales programs and economic projections. Granting of extended credit (a practice which overseas is used to a greater extent than in the United States, in selling industrial products) and other local marketing customs must be understood. Transportation, taken for granted domestically, can be a serious handicap to marketing where rail and even truck facilities may be very limited. Finally, channels of distribution, packaging and shipping play a key role, and United States methods are not always readily accepted.

The final criterion to be discussed is Personnel, and the emphasis here is on:

Availability

- Technical
- Managerial
- Business
- Labor

Training

Since, ultimately, a project must be implemented by people, the availability of all types of personnel becomes one of the most significant criteria. With the exception of a key-management or technical specialist, it is essential that the American company rely entirely on nationals. In addition to the sheer necessity for manning an operation, the training of personnel must be included in the cost of operation, as an important factor in the economics of the project. Starting up a new continuous chemical operation with a recently recruited labor force can be very expensive.

In summary, criteria for a foreign investment include all the factors for a domestic-investment decision. However, "investment climate", which includes political and economic stability, special incentives and taxation, requires considerably more attention because most of these items, domestically, are well defined and taken for granted. Finance and corporate structure also require a broader range of study for an overseas investment. The other criteria, such as technology, marketing and personnel, are more closely akin to the domestic evaluations, but must be adapted to the local conditions.

These comments have touched only briefly on the criteria for foreign investment, any one of which is a subject in itself. While each of the criteria demands study and deliberation, making a profit for the American company's stockholder must always be the overriding standard for a foreign-investment decision.

* * *

Three Applications of Break-Even Methods in Economic Analysis

By Winfield Hutton and J. T. Powers*

Break-even charts are being used with increasing frequency in economic decision-making. This article indicates how the basic break-even model may be adapted to three specific situations which often arise in economic analysis: (1) multiproduct operations, (2) variation in selling price and the related problem of price-output determination, and (3) mechanization decisions. Each of these modifications of the basic break-even model involves manipulation of the general break-even function:

$$S = \frac{F}{1 - V} \tag{1}$$

where S is the break-even sales volume, F is total fixed costs, and V is the ratio of total variable costs to expected dollar net sales volume.

I. MULTIPRODUCT OPERATIONS

Most firms produce more than one product, thus break-even analysis should be adapted to multiproduct operations

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*The authors are, respectively, Assistant Professor of Economics, Hunter College of the City of New York, and Manager, Peat, Marwick, Mitchell & Co. Dr. Hutton was on the faculty of the School of Industrial Management, Georgia Institute of Technology, while this article was in preparation. The authors appreciate the comments of Mr. G. D. Smith, Rich Electronic Computer Center, Georgia Institute of Technology.

and to changes in product mix. As might be expected, the break-even volume varies with the product mix. The greater the proportion of total sales accounted for by the products with higher-than-average margins, the lower the break-even volume.

A specific example illustrates how variation in product mix can be represented graphically without introducing undue complexities. Assume a firm produces five products (A, B, C, D, and E) with variable cost percents (V) of 60, 65, 70, 75, and 80, respectively, and total fixed costs of $100,000. Substitute these different variable cost percents in the general break-even function of equation (1) and calculate five different break-even volumes, assuming successively that each of the five products is the only one sold. Plot these five points on a chart (see the lower curve in Figure 1), with the horizontal axis representing variable cost percents and the vertical axis sales dollars, connect the points, and the resulting curve is a break-even zone for product mixes representing all possible combinations of the five products. The break-even zone for this firm (lower curve in Figure 1) will lie between $250,000 (assuming product A is the only one sold) and $500,000 (assuming product E is the only one sold).

The break-even volume for a particular mix of these products will lie on the break-even zone formed by the lower curve in Figure 1, at a point depending upon the average variable cost percent (V) for the product mix. The average variable cost percent for the product mix is determined (Table 1, below) by weighting the variable cost percent for each product by its percentage of total sales dollars, adding the cross-products, and substituting their sum for V in the general break-even function (1). The average variable cost percent (V) for this product mix is 69.5 percent, and the break-even volume (point M in Figure 1) would be around $328,000:

$$\frac{\$100,000}{1 - 0.695} = \$327,869.$$

TABLE 1

DETERMINATION OF AVERAGE VARIABLE COST PERCENT FOR A PRODUCT MIX

Product	Variable Cost Percent	Percent of Total Sales	Cross-Product
A	60	20	0.120
B	65	20	0.130
C	70	20	0.140
D	75	30	0.225
E	80	10	0.080
Sum	XX	100	0.695

Source: Hypothetical

This is the ordinate on the vertical axis of Figure 1 which corresponds with the abscissa variable cost percent of 69.5 on the horizontal axis.

A profit curve can be added to enhance the analysis in Figure 1. This curve represents the total sales required to obtain a specified profit margin. Add the desired profit percent to each variable cost percent and substitute in the general break-even function (1) to calculate the points through which the profit curve (upper curve in Figure 1) will pass. For example, assuming a desired 10 percent profit margin, point A' is calculated as follows:

$$\frac{\$100,000}{1 - (0.60 + 0.10)} = \$333,333.$$

The upper curve in Figure 1 shows the sales required to make a 10 percent net profit (before taxes) at each average variable cost percent level for all possible combinations of

the five products. Assuming the same product mix as in Table 1, sales would have to be approximately $488,000:

$$\frac{\$100,000}{1 - (0.695 + 0.10)} = \$487,805$$

to make a 10 percent net profit. This point is M' on Figure 1, the sales volume on the profit curve corresponding to an average variable cost percent of 69.5.

II. VARIATIONS IN SELLING PRICE AND THE RELATED PROBLEM OF PRICE-OUTPUT DETERMINATION

Economic analysts often must determine the effect of price changes on volume-cost-profit relationships. Also, locating the price and output at which profit would be maximized under a given set of circumstances is one of the main problems of traditional microeconomic analysis. Both these tasks can be accomplished through break-even analysis if the basic break-even model is modified to include variations in selling price. The following example demonstrates this.

The variable cost percent (V), hence the break-even volume (S), varies inversely with the unit sales price. For example, if the unit variable cost is $0.60 and the unit sales price is $1.00, the variable cost percent (V) is 60 (or $0.60/$1.00), while if the unit sales price were $0.90, the variable cost percent would be 67 (or $0.60/$0.90). The lower curve in Figure 2 shows how the break-even volume changes as unit sales price is varied between $0.75 and $1.00, given total fixed costs of $100,000 and a variable unit cost of $0.60. To derive a function depicting the relationship between selling price and break-even volume, select about five different unit sales prices, calculate the variable cost percents (V), and substitute in the general break-even formula (1) to obtain break-even volume at each selling price.

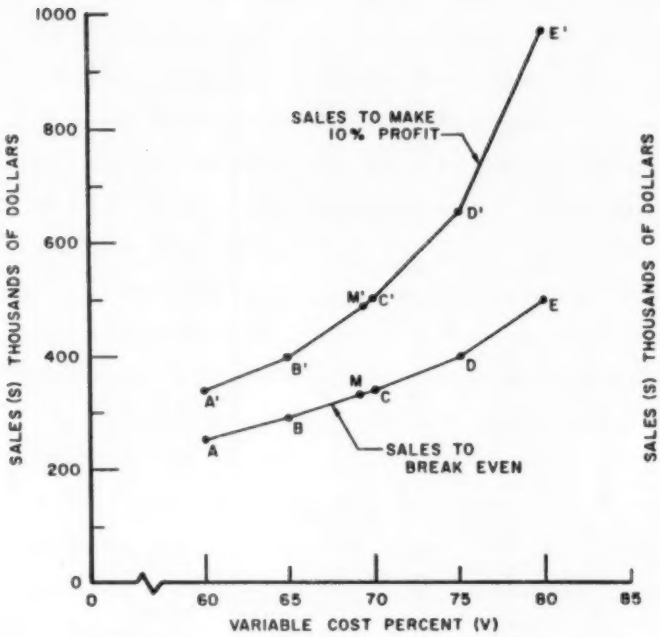

FIGURE 1. APPLICATION OF BREAK-EVEN ANALYSIS TO MULTI-PRODUCT OPERATIONS.

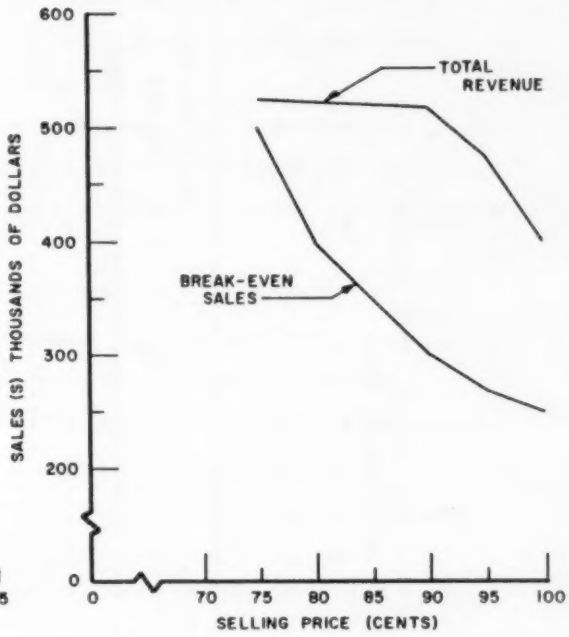

FIGURE 2. APPLICATION OF BREAK-EVEN ANALYSIS TO PRICE-OUTPUT DECISIONS.

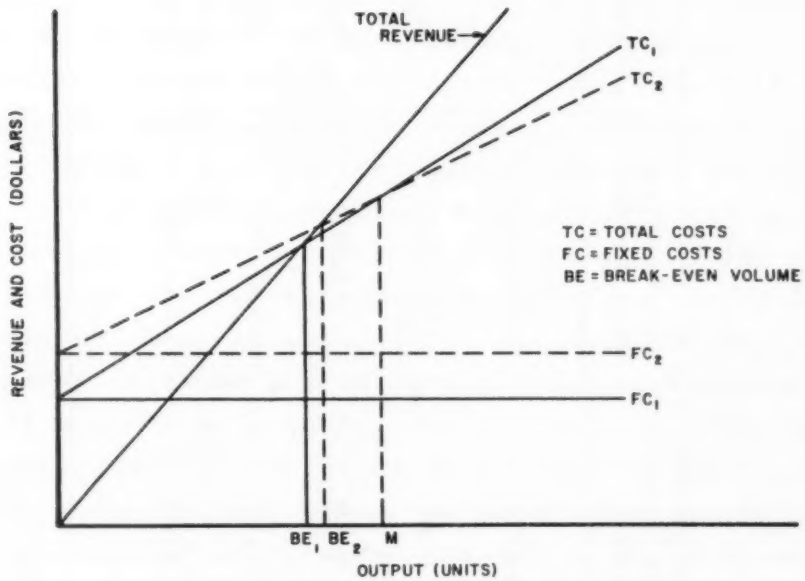

FIGURE 3. APPLICATION OF BREAK-EVEN ANALYSIS TO MECHANIZATION DECISION.

TABLE 2

DATA INVOLVED IN DETERMINING, BY BREAK-EVEN ANALYSIS, THE PRICE AND OUTPUT AT WHICH PROFIT WOULD BE MAXIMIZED

Unit Sales Price	Anticipated Unit Sales	Total Revenue	Total Costs	Profit	Break-Even Volume
$0.75	700,000	$525,000	$520,000	5,000	$500,000
0.80	650,000	520,000	490,000	30,000	400,000
0.90	575,000	517,500	445,000	72,500	300,000
0.95	500,000	475,000	400,000	75,000	270,000
1.00	400,000	400,000	340,000	60,000	250,000

Source: Hypothetical

The break-even curve connecting these points (as in Figure 2) will always be a rectangular hyperbola due to the nature of the general break-even function ($y=k/x$).

A total revenue curve must be added to the break-even curve in Figure 2, to determine the price and volume at which profit would be maximized. This total revenue curve is based on the hypothetical data in Table 2.

Profit would be maximized at that price-output combination in Figure 2 where the spread between the total revenue and break-even curves is greatest. By inspection (verified by the data in Table 2), this is at a price between 90 and 95 cents, although slightly closer to the latter. Note that the spread between the total revenue and break-even curves on the chart does <u>not</u> show <u>dollars</u> of profit, but merely the <u>relative</u> magnitude of profits at different selling prices.

III. MECHANIZATION DECISIONS

Mechanization decisions arise with increasing frequency during the current automation era, and the basic break-even model can be adapted to their solution. For example, if further mechanization would increase fixed costs by $200,000 and reduce variable costs by 30 percent, would it be wise to mechanize? Figure 3 shows the application of break-even analysis in solving this problem; the solid lines represent the existing situation before mechanization, and the dashed lines represent the relationships which would result from mechanization. Mechanization would obviously be unprofitable if forecasted sales were less than the new break-even volume (BE_2). At outputs between BE_2 and M, the firm would not lose money by mechanizing, but it would not make as much profit as before mechanization. The firm should definitely mechanize if forecasted sales are greater than M, as the firm would then clear a larger unit profit than under the old production function.

IV. SUMMARY

This article has described the application of break-even methods to three specific problem areas in engineering economics: (1) multiproduct operations, (2) selling-price variations and price-output determination, and (3) mechanization decisions. In addition, break-even analysis may be applied to many other situations. For instance, it can be used to depict the effect of changes in finished goods inventories on the break-even point of a manufacturing company or the effect of changes in a variable-cost item such as raw-material prices or wages.

As a tool of analysis, break-even charts are simple and direct. They present a clear view of the major volume-cost-profit relationships facing a firm and the impact of alternative courses of action upon these relationships. Consequently, break-even charts are gaining increasing acceptance, expecially where readily understandable, visual presentations are desired to show the effects of alternatives in decision making.

* * *

A number of papers on the general subject of break-even analysis have been published in The Engineering Economist. Those available appeared in Vol. 3, No. 4 and are:

"Modernizing the Break-Even Analysis", by Benjamin Caplan;

"A Simplified Formula for Break-Even Analysis", by Ernest H. Weinwurm.

Design for Economy: Must It Be For Longer Product Life?

By Gerald W. Smith, Assistant Professor
Department of Industrial Engineering
Iowa State University

One criterion for selection of the most economical of several alternatives is economic life. Generally speaking, the longer the service life, the more desirable the alternative; lengthening the service life of a piece of equipment makes the equipment more desirable from the viewpoint of economy.

It would appear, therefore, that a common goal of product design-and-development groups of all firms should be increased economic life for their product (without proportionately increased cost for the product). As a corollary, it would seem that product design-and-development should resist all changes which could reduce economic life for their product (without compensating product economies). This is not necessarily so. An exception can be illustrated by the fluorescent tube problem[1] where a plant adopts a policy of replacing the fluorescent tubes over the production area whenever they fail. Beginning with 1,000 new tubes, and replacing failures promptly, the number of replacements per month over a 15-month period are as follows:

Time in months (t).....	1	2	3	4	5	6
Number of failures [f(t)]...	5	17	22	39	78	97

t.....	7	8	9	10	11	12	13	14	15
f(t)....	123	131	138	140	141	143	149	150	151

[1] See William T. Morris, Engineering Economy, Richard D. Irwin, Inc., Homewood, Ill., 1960. Page 237.

The plant is considering a policy of simultaneously replacing all the tubes at the end of some period T. If this is done the replacement cost per tube is estimated to be $0.67. Under present conditions the replacement of tubes individually costs about $2.20 each. Find the value of T which will minimize expected costs.

Assuming instantaneous replacement of all failures, and a policy of replacing all units (good and bad) every T months:

(Average Monthly Cost = A)

T

4 $$A_4 = \frac{670 + (5+17+22+39)\ (\$2.20)}{4} = \$213.15$$

5 $$A_5 = \frac{670 + (5+17+22+39+78)\ (\$2.20)}{5} = \$204.84$$

6 $$A_6 = \frac{670 + (5+17+22+39+78+97)\ (\$2.20)}{6} = \$206.26$$

From this one might adopt a policy of simultaneous replacement every 5 months. (If one interpolates at, say, 5½ months, an even lower cost, $195.47, results.)

The average life of the above tubes can only be estimated from the data given; if replacements stabilize at 150 units per month, one can state that average life is equal to

$$\frac{1,000}{150} = \underline{\underline{6.67 \text{ months}}}$$

and that the average monthly cost of replacing fluorescent tubes whenever they fail will stabilize at:

$$(150)(\$2.20) = \underline{\underline{\$330 \text{ per month}}}\ .$$

In its present usage, then, the minimum average cost (for integer values of T) is $204.84 per month. This cost could be reduced if longer-lived tubes were developed. It also could be reduced if tubes of more uniform lives were developed. Assume that absolutely uniform tube life could somehow be developed: How long does the life of the new product need to be, so that it proves to be at least as economical as the present fluorescent tube?

Let X = average service life of the new tube, in months.

Set average monthly costs of the present and new tubes equal:

$$\$204.84 = \frac{\$670.00}{X} ;$$

$$X = \underline{\underline{3.27 \text{ months}}} .$$

Here it can be seen that, because of replacement policy, uniformity of tube life becomes a goal desirable enough that it may be economically advisable to adopt a new design having a life less than that of its predecessor, providing the new design results in a more uniform tube life. On the other hand, uniformity of tube life will make no difference to those firms which adopt a failure-replacement rather than a simultaneous-replacement policy. For these firms, the old design would be more economical.

Product design-and-development may be well-advised to re-examine their goals, on the basis of examples such as the preceding. It may well be that two lines of tubes should be offered by a manufacturer: the uniform-life tube for users following a simultaneous-replacement policy, and a long-life tube for users following a failure-replacement policy.

* * *

COMMENT

A Comment on: The review of Edward A. Ravenscroft's article, "Return on Investment - Fit the Method to Your Need", by Professor Lawrance F. Bell (The Engineering Economist, Fall 1960, Vol. 6, No. 1, p. 24). The article had been presented in the Harvard Business Review, March-April, 1960, Vol. 38, No. 2.

By: Edward A. Ravenscroft
Executive Vice President
Abbott Laboratories

It is difficult to sit down and calmly and objectively write an answer to the criticisms leveled at one's manuscript when one has spent well over a decade in the study and application of engineering economics and two years in the preparation and revision of the manuscript itself, and then learn that one's brainchild "illustrates, in one compact article, many of the important [common] sources of confusion", that it contains "unsophisticated suggestions", that it "is badly misleading" and is "attempting the futile alchemy of reconciling estimates and calculations" and finally is a "misapplication of both accounting concepts and principles of engineering economy".

When the person making those statements says that rate of return is not a ratio, I begin to wonder about his knowledge of the fundamentals upon which are based the concepts of return on investment, time value of money, etc.

It is quite apparent to me that he has missed completely the main concept of my entire exposition, namely, that when considering return on investment the use of arithmetic averages is inadequate and another type of "average" is needed -- one that reflects the time value of income (or outgo). Perhaps he has forgotten that averages are computed in many different ways in the field of statistics for example; and further, in the engineering analysis of the thermodynamics of heat exchangers one uses the logarithmic average (log mean) temperature difference in place of an inadequate arithmetic average.

Certainly there are many different ways of computing averages. To me, discounting is a way of doing just that -- finding an average rate of return on investment. To those who read this and still won't accept this concept I can only suggest they again read that part of my article which follows the sub-title "The True Average" and continue until the sub-title "Operating Return" is reached. There is little more that I can add here to what is in those paragraphs. They were criticized and rewritten many times to meet the suggestions of a dozen or so persons of wide experience in academic and business circles who read the manuscript before it was sent in for publication.

Another thing that seems unfortunate is that my critic has classified "Operating Return" and "Equity Return" as useful "historical" measurements without any admission that they also are applicable to estimates of the future when comparing the differences between alternate courses of action. I can assure you, that there are many business situations where the decision maker must look ahead at the effect of his decision on operating efficiency and/or on stockholders' evaluation with as much or greater concern than just the effect on cash flow -- which is, of course, the basis of engineering economic evaluation. So without further ado, let us admit that engineering economic evaluation is not the only method nor the only correct method which business has and must use in financially looking into the future even without going beyond the broad concept of return on investment.

Apparently my discussion of that concept appears to my critic to be "attempting the futile alchemy" of reconciling mathematically the various ways of calculating "return" for different purposes. Further, I wish to assure him that there is no confusion in my mind between "accounting concepts and the principles of engineering economy" nor between the "different administrative processes -- managerial control and economy decision making". I am well versed and long experienced in all of these fields. I am sorry my critic was

unable to grasp, as many others did, the overall simplicity of the link which I see between the various ways of calculating and using rates of return in business management. Unless this link, the concept that discounting is a method of averaging, is understood and accepted there is little use in discussing the rest of my article. Likewise, for purposes other than economic evaluation, one must be willing to accept other definitions of income and investment than those inherent in the cash-flow techniques of economic evaluation. In fact, most of my critic's fault-finding observations become quite inappropriate when these two basic concepts become understood and accepted.

However, lest we all take too seriously the importance of precise calculations in this field, may I again say: "After all, the rate of return concept is only a yardstick which serves to help with part of the many tangible and intangible considerations that lead to a management decision. The evaluator is somewhat like a doctor trying to diagnose a patient with different kinds of symptoms. Good judgment is needed in making the final choice."

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1962 SUMMER SYMPOSIUM
Engineering Economy Division
American Society for Engineering Education

June 16-17th, 1962
UNITED STATES AIR FORCE ACADEMY
Colorado Springs, Colo.

Write to: Professor G. J. Matchett
Illinois Institute of Technology
Chicago 16, Illinois

Limits of the Scientific Method

A Review of: SCIENTISM AND VALUES
Edited by Helmut Schoeck and
James W. Wiggins
D. Van Nostrand Co., Princeton, N.J.
Copyright 1960 by William Volker Fund
170 pp. $6.50

By: Ernest H. Weinwurm
Professor of Accounting
De Paul University

The age-old argument, as to the applicability of the "scientific method" used for research in the natural sciences, has been revived of late. There are various reasons for this development. First of all, the important discoveries of recent years, which opened up new vistas in the physical sciences, have greatly strengthened and enhanced the prestige of the methods which made possible such amazing results. The far-reaching concepts of cybernetics also suggest a universal method of research, encompassing all types of sciences. Moreover, there has been an invasion of the area of traditional business-management methods, by experts trained since World War II in the research methods of the physical sciences (best known as operations research). Their claims that adoption of the "scientific method" could make a major contribution,toward a solution of the vexing problems of managerial-decision making, raised once again the question as to the universal significance of that method.[1]

To the industrial engineer, and to the engineering economist, this is a problem of much more than theoretical importance; for they have a stake in both the physical and the social sciences. The physical sciences are reflected in production techniques and

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[1] See "Management Science", in Fifty Years of Progress in Management (Management Division, American Society of Mechanical Engineers, New York, 1960), for a list of articles by this reviewer, dealing with this problem.

machines; the social sciences are represented by the individuals who manage enterprises and operate production facilities.

Traditionally, the engineer has been inclined to side with the "universalists" who have been emphasizing general use and applicability of the "scientific method". He has given little, if any, attention to the social effects, and implications, of his activities, in the strongly-held belief that these were considerations outside his particular area of interest and responsibility. However, there are strong doubts as to whether this convenient but one-sided attitude can or should be maintained any longer.

For example, to look at the problem of automation merely from the viewpoint of technology, while disregarding its economic and social impact, could lead to dangerous conclusions. The same is true for the over-all problem of industrial relations in general. There is a widely-held feeling that the present condition of intermittent warfare holds great danger for the nation as a whole, and needs to be replaced by some better arrangement. These and many other issues indicate that a review, and perhaps a revision, of the engineer's traditional attitudes may be in order. Such an attempt would lead, unavoidably, to a re-appraisal of the proper methodological tools for the physical and the non-physical (social) sciences; and the re-appraisal might be an essential prerequisite for a better understanding of the grave problems at stake.

Opponents of the concept of "universality" have coined the term "scientism", for practices leading toward abuse and overextension of the scientific method, beyond its proper field. Their arguments are forcefully presented in the collection of papers here under review, which were contributed by writers in various areas of the social sciences. The editors of the volume are members of the department of sociology and anthropology at Emory University, Atlanta, Georgia; and their background must be kept in mind, in making proper appraisal of their writings.

As may be expected in a venture of this kind, the contributions are of unequal significance, and there are unavoidable repetitions of the fundamental arguments. Space does not permit

discussion or analysis of the individual papers. However, an effort will be made to present the principal positions, using statements which appear most pertinent, but not referring to the particular writer involved.

The universalist position of an "integrated science" is based on two crucial assumptions. One, formulated by Galileo and actually employed in the natural sciences, contended that only quantities, or facts reducible to quantities, could be admitted as real for scientific research. The other stated that only material objects, and their interactions, could be regarded as legitimate objects of science. These assumptions would thus exclude all value concepts from the realm of science, although values are part and parcel of human existence.[2]

Thus a special problem arises for all those who advocate a total unity and integration of science; namely, whether the reality of man, permeated with values as it is, can be fully understood in terms of value-free concepts and theories.[2] Whatever individuals do is influenced and determined by values; and this includes even their research in the physical sciences. Yet the key to decision making is not the knowledge provided by the sciences. It is the value commitments of a civilized humanity which determine, ultimately, what the ends and goals shall be.[3]

There are two groups of valuations, each having its own particular significance for science. The first refers to the over-all value commitments and valuations of a given culture, or historical period, with respect to science in general; the other refers to the specific value commitments of the investigator, if he is to be classed as a scientist.[4] Once we accept scientific, rather than non-scientific, procedures of investigation, we must also accept the complexus of valuations summed up in the terms

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[2] See the volume under review, p. 3.

[3] Ibid., p. 5.

[4] Ibid., p. 7.

"standards of research".[5] In a superficial sense, the demand for objectivity means that the scientist should be guided only by facts, and by logically-sound inferences from them. Yet the facts are not always well defined. Selection and demarcation of facts are determined by the basic assumptions, and by valuations which guide the investigator.[6]

Thus it becomes apparent that value considerations and assumptions cannot be eliminated from scientific research. However, since values are so broad, and are virtually uncontested in the physical sciences, they are invisible, so to speak, to the average researcher who does not look into the more remote background of his work. The situation is quite different as far as the social sciences are concerned. The question arises as to whether or not those considerations can be minimized here as they actually are in the physical sciences. The answer, of course, is in the negative, as far as the contributors to the book under discussion are concerned.

To them, scientism is the profoundly unscientific attempt to transfer, uncritically, the methodology of the physical sciences to the study of human action (the social sciences). Both fields must be studied by the use of reason. But only human beings possess a rational consciousness; only they possess free will and consciousness, and only they can and must choose their course of action. To ignore this primordial fact about the nature of man is to misconstrue the facts of reality, and therefore to be profoundly and radically unscientific.[7] Man's actions are self-determined by the choices his mind makes.[8]

The determinists profess that they may be able to determine what man's choices and actions will be. But if our ideas are

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[5] Ibid., p. 7.

[6] Ibid., p. 8.

[7] Ibid., p. 159.

[8] Ibid., p. 161.

determined, we have no way of freely revising our judgments in learning the truth. The various brands of determinists -- behaviorists, positivists, Marxists, etc. -- implicitly are compelled to claim special exemption for themselves from their own determined systems.[9]

Therefore, true science decrees determinism for physical nature and free will for man, and for the same reason -- that everything must act in accordance with its specific nature.[10] The key to scientism is its denial of the existence of individual consciousness and will. This takes two main forms: applying the mechanical analogies, from the physical sciences, to individual men; and applying organismic analogies to such fictional wholes as "society". The latter course attributes consciousness and will, not to individuals, but to some collective organic whole, of which the individual is merely a determined cell. The scientistic method in the study of man is, almost wholly, one of building of analogies from the physical sciences.[11]

As happens not infrequently, critics have a tendency to swing far out in the opposite direction. Thus the writer here, in opposing scientism, comes out against all kinds of measurements in the social sciences. He states that the concept of measurement implies the necessity for an objective extensive unit to serve as a measure. But the magnitudes in consciousness are necessarily intensive, and therefore not capable of measurement. Not only measurement, but the use of mathematics in general in the social sciences and in philosophy, is an illegitimate transfer from physics.[12] He also objects to the economic concept of equilibrium, since there is never such a state in economics, or politics, as there is in physics; there is but a tendency in this direction.

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[9] Ibid., p. 162.

[10] Ibid., p. 163.

[11] Ibid., p. 165.

[12] Ibid., p. 166.

Moreover, the term has emotional connotations. Since man, by his very nature, must keep acting, he cannot be in equilibrium while he lives; therefore, the concept is impossible even as an ideal.[13]

The disciples of scientism implicitly assume that the methodology of physics is the only true scientific methodology. This is, briefly, to look at facts, then frame ever more general hypotheses to account for the facts; and then to test these hypotheses by experimentally verifying other deductions made from them. But this method is appropriate only in the physical sciences. In the study of human action, the proper procedure is reversed. We begin by fully knowing the abstract axioms, and build upon them by logical deduction, introducing a few subsidiary axioms to limit the range of the study to the concrete applications we care about.[14]

Another contributor points out that the specific methods of the natural sciences do not, and cannot, encompass the range of social phenomena; and will, in some crucial respects, produce results that are as meaningless, scientifically, as they are harmful, humanly and socially. The social sciences cannot be expected to do for society what the natural sciences have done for nature, until they have developed their <u>own</u> methodology and have defined their proper data and criteria of truth -- the truth that is theirs to seek.[15]

As theory, pure science is concerned with the reduction of diversity to identity, and thus to order. Practical scientific research is concerned with simplification. But when applied to problems of human society, the process of simplification, pushed to its logical conclusion, must lead, in theory, to the deletion of those unique and imponderable factors -- nuances, if you will -- which endow life with zest, flavor and creativity, and, in practice, to the repression of diversity and thus to tyranny.[15]

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[13] Ibid., p. 167.

[14] Ibid., p. 171.

[15] Ibid., p. 222.

Science seeks to approximate the truth about the world only within the limitations of specific and rigorously defined contexts. No true scientist will claim more; no educated layman should expect more. Yet the vulgarization of science -- scientism -- has led many people, including not a few scientists who have lost sight of the philosophical foundations of their craft, to assert that science holds the key to all problems of human experience, and that those problems that cannot be dealt with by simplification, or abstraction, are either trivial problems or no problems at all.[16]

The blight of scientism has spread, in all sectors of modern life. In the arsenal of demagoguery, scientism is the most powerful secret ideological weapon. For example, complex international problems can be swept conveniently under the rug by reducing international relations to economic equations.[16]

Since the social sciences are concerned with human action, an explanation of data can hardly be satisfying and valid unless it relates "objective" social phenomena to human purpose, intention, and values. This approach is understandably at odds with that of the natural scientist.[17]

Even if there is agreement about a fundamental distinction between the methodology of the physical and the social sciences, there yet remains the problem of objectivity or value-free approach in the research of the social sciences. This dilemma has agitated social scientists for a long time.

The outstanding figure in this argument is the famous German sociologist, Max Weber, who made his principal contributions around the turn of the century. Weber advises the social scientist to recognize that, in dealing with social problems, he cannot escape the value problem; he must recognize values, and deliberately and openly give them a place in theoretical systems

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[16] Ibid., p. 223.

[17] Ibid., p. 224.

("ideal types") which he can then use somewhat as the physical scientist uses his mathematical formulas. The social scientist has no basis for his science but beliefs, and thus Weber makes social science a function of belief.[18] Weber lays down a rule for academic objectivity; the teacher must make it clear to his audience, as well as to himself, which of his statements are statements of logically deduced or empirically related facts, and which are statements of practical evaluation.[19]

The student of society can make use of many of the findings of positive science. We are constantly running into things of which we were unaware until they proclaimed their objectivity by impinging upon our senses. On the other hand, a large part of the subject matter, in the study of society, does consist of the subjective element in human beings. History shows that many highly erroneous, or fantastic, opinions have been active influences on human behavior.[20]

SUMMARY

It was the aim of this review, as indicated at the outset, to give the reader a feeling of the flavor which permeates the book, to let him appreciate the strong opinions held by the various writers in their condemnation of scientism. Obviously, there was no room here for a critical appraisal of the various questions raised, and concepts presented, by these authors, although to do such appraising would be highly desirable for a better understanding of the issues at stake.

However, it may be assumed that the reader will have recognized, at least, that here are problems of great significance; that the question of the universality of the scientific method is

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[18] Ibid., p. 38.
[19] Ibid., p. 97.
[20] Ibid., p. 98.

one which requires and deserves attention and careful consideration. It is time to do away with the smug prejudices which have been, and still are, largely dominating discussions among scientists and engineers.

One question of very great importance concerns the need for clarifying the assumptions underlying "generally accepted" statements and opinions which are taken for granted and repeated so often that nobody cares to analyze them. The importance of values and, therefore, of a variety of values competing for acceptance, must be kept in mind. Those who claim that they have solutions for particular social problems should be called upon to explain the premises which underlie their conclusions. To do so should be a general requirement, at least for those who consider themselves practitioners of the "scientific method".

Perhaps few engineers will find time to read this book from beginning to end, and to fight through its often complex phraseology and terminology. But even if they merely read some of the papers, they will get a better idea of a field which will continue to be marked by debate and heated argument for a long time to come.

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"EXTENSION OF AVAILABLE INTEREST TABLES"

A few copies of this 42-page reprint are still available. There is an introduction which presents examples of the use of the tables, which were prepared at Syracuse University by Ralph O. Swalm. The price is $1 a copy (25% discount on purchases of more than 25); please make check or money order payable to The Engineering Economist.

BOOK REVIEW

A Review of: STATISTICS OF EXTREMES
By Emil J. Gumbel
Columbia University Press
New York, 1958 375 pp. $15.00

By: John E. Ullmann
Professor of Management
Chairman, Department of Management,
Marketing and Business Statistics
Hofstra College

Engineering economists are having to pay increasing attention to a group of design problems for the analysis of which Gumbel's book provides the theoretical basis. Virtually all machines and structures that operate under conditions set by natural phenomena are subject to extremes, that is, to a succession of maximum or minimum conditions, occurring periodically and varying randomly in a certain manner. To provide against such emergencies, something better is needed than the traditional "factors of safety" which turned out to be either inadequate, in many instances, or led to overdesign.

A brief listing of applications will indicate the scope of these problems. One of the best known examples concerns floods and droughts. A system of irrigation storage reservoirs or of flood controls is only as good as its ability to deal with the worst that may happen. While it is true that no matter how high a flood is there will always be a worse one, it is much more useful to have an estimate of how likely it is to have a flood, say, 25% higher than the worst met with so far. In the past, this has led to such rules as building a dam so that it will withstand double the worst flood of the last N years for which there were data. In one example cited by Gumbel, the Mississippi at Vicksburg, this would lead to flood works unlikely to be used to capacity for 250,000 years. At the same time, recurring floods in the Connecticut Valley, and elsewhere, show the inadequacy of other designs.

A systematic analysis of both floods and droughts is also required for the planning of power stations. A dam which is built too high will cost more in direct proportion, because its crest will usually become longer as its cross section increases. Further, a dam is virtually a permanent structure. If there is delay in putting it into commission, there is a direct loss of revenue and there will be greater interest charges during the longer construction period.

Many similar situations exist. Rainfalls in connection

with sewer construction, snowfalls and the purchase of removal equipment, breakdown voltages or overload ratings in electrical equipment could be reviewed by the methods described by Gumbel. A most critical group of applications, however, is that of material failures.

This applies not only to repeated tests on standard specimens, with the distribution of failure points as the experimental variable. It is even more critical in the design of vehicles and structures subject to wind, water pressure, inertial and impact stresses. Gumbel has ruefully noted elsewhere that engineers appear to have learned little between Sir Thomas Bouch's admission that he had hardly considered wind pressure in designing the first Tay Bridge and the recent structural failures of Comets and Electras. Ship hulls still occasionally break up because extremes of wave action were not adequately provided for, and a large portion of the world's fleet probably pays extra fuel costs for hauling unnecessary extra dead weight.

Gumbel's approach to these problems is to rank the N readings in ascending or descending order and then to plot them on special probability paper, which has the experimental readings vertically and three axes horizontally, a reduced variate, used later for fitting lines through the points, a probability scale used to plot the points, and a "return period" scale. If the cumulative probability of an event's being x or less is given by $P(x)$, then the return period is $T(x) = 1/[1 - P(x)]$, or, put more simply, one chance in $T(x)$. The term "return period" derives from the use of this approach in flood studies, where annual phenomena are considered. The plotting points are $[x, P(x)]$. All N phenomena are ranked in order. The value of $P(x)$ for the m^{th} point from the bottom is then given by

$$P(x)_m = \frac{m}{N + 1}$$

So far, this is like using normal probability paper. Where Gumbel's method differs is in the use of double exponential probability paper. This is easily noted, because the point for which the reduced variate is zero corresponds to $1/e$ or 0.3679 rather than the 0.5 familiar in the normal paper.

Since the $P(x)$ values depend on the value of N only, i.e., on a practically limited range of whole numbers, it is possible to have tables for much of the computation of $P(x)$, of the straight lines fitted through the experimental points, and for the confidence limits which can also be readily plotted. It is especially useful to note that the extrapolated confidence limits are located plus or minus a fixed

distance parallel to the fitted straight line on the extremal probability paper. For example, the 95.45% confidence limits are located plus and minus 3.0669/b from the straight line where b is its slope. Of course, extrapolations are most interesting for practical purposes.

So far, we have considered mainly the first asymptote, the straight use of the double exponential distribution. While this is valuable for many of the examples outlined, it is not found appropriate in practice for some floods nor for the behavior of metals under fatigue. Wherever the extremes approach an asymptote rather than increase with time, the second or, more usefully, the third asymptote is used. The latter is also known as the Weibull distribution and is now widely used in reliability statistics.

The Weibull distribution requires the estimation of three parameters. One of them, if it exists, is the asymptote of the extreme value, and there is a method for testing its existence statistically. Thus we can determine if there exists a stress for a certain metal below which the stresses can be repeated infinitely without causing fatigue fracture. Again, extensive mathematical aids are furnished to make computations easy. An extremal paper with a logarithmic axis for the experimental data is used here. If there is an asymptote, a straight line in terms of the reduced variate can be fitted to the logarithmic data axis; if not, a modified logarithmic curve is derived, asymptotic to the minimum or maximum value previously computed.

The foregoing summaries of applications and procedures cannot, of course, do justice to the scope of Gumbel's study. He has drawn upon his own pioneering work as well as on a large section of the work done elsewhere, and his book is the first, and to this reviewer's knowledge, only, text which encompasses the entire field. It deserves careful study, and, it should be added, it is no "cookbook"; it demands a fair degree of reader knowledge. However, sufficient examples are given to help with practical use, and there is a full bibliography of other applications.

Much further work must be done in this field, of course, before all the manifold erratic behavior of nature can be interpreted. One could even see a menace in the possibility of so accurately interpreting quality that collapse of the product, and thus the replacement, might be timed with accuracy. For the moment, however, we can look at many different types of events, with the knowledge that further experimental work, by which the theory can be extended, certainly deserves the strongest support.

* * *

REVIEW

A Review of: "CALCULATING THE RATE OF RETURN ON CAPITAL PROJECTS",
By Anthony Merrett and Allen Sykes
The Journal of Industrial Economics
Volume IX, No. 1, November 1960

By: Warren E. Staudt, Economic Evaluation Engineer
Development Appraisal Department
Atlas Chemical Industries, Inc.

The stated purpose of this British paper is to reach a definitive conclusion in the debate on the relative merits of rates of return (on capital projects) which incorporate discounting of cash flows and those which do not. The implied rate of return (IRR), which is known in this country by such terms as interest rate of return, yield, and profitability index, is to be compared with the accountants' rate of return (RR) or return on original investment. The authors also state that they will show the usefulness of IRR as an aid in risk assessment.

Merrett and Sykes have defined the IRR and compared it with RR under several assumptions. The cost of capital for a firm has been discussed both with and without a capital-rationing situation. The risk inherent in a capital project is described and reasons are given to support the authors' contention that IRR is a satisfactory measure of risk. The deficiencies of IRR are described and possible remedies are suggested. The article is concluded with a summary of the areas in which IRR is purported to be superior to RR.

Most of the arguments given for using IRR are convincing and appropriate. However, the IRR has been overrated by the authors in a few areas, particularly that of risk assessment. The contention is made that risk can be measured by the return available on the outstanding obligation in successive years of a project's life (IRR).

We might question the usefulness of IRR to measure risk if we look at two projects, each requiring the same initial and subsequent investments at the same points in time. One of the investments is for a new steam boiler to serve a multiproduct plant. The resultant cost savings over the 20-year estimated life of the boiler would give a 10%/year IRR. Our second investment is for specialized equipment to produce a product which is a complete innovation. Revenues are expected to be high during the first two years of production, after which competition will cause a decrease in sales revenue and the eventual dropping of the product after five years. There is some question as to the market acceptance

of this product, but the best estimate of the IRR is 20%/year. I find it hard to believe that we have less risk in this 20% investment than we have in the 10% investment for a boiler at a plant where we plan to continue operating indefinitely.

Using an example of the authors, a well-sited multipurpose building, we can again see the lack of adequacy of IRR as a risk measure. The authors state that the risk in investing in the above building is solely in the revenue stream. The capital could always be recovered (presumably with appreciation in value). If we were to erect an identical building on a poor site, but expected an identical revenue stream, our IRR's would be identical, assuming identical investment and timing. The risk of not being able to recover our capital at the poor site is not reflected in the IRR.

The merits of IRR are otherwise correctly described. The authors have mentioned one attribute of IRR which is not usually shown in a paper of this type, the ability of IRR to take into account the way tax accruals benefit a firm. This is just one type of timing problem, but one which has not been recognized by many authors.

At a number of places in the paper, there is ambiguity as to whether cash flows have been discounted on a before-tax or an after-tax basis. Most of the uncertainty occurred in comparing cost of capital with various profitability measures.

In discussing investment criteria, Merrett and Sykes suggest that projects should be accepted if their IRR is greater than the firm's <u>marginal</u> cost of capital. This is a sound theory, but in practice the true marginal cost is difficult to determine if one accepts the theory that the debt-to-equity ratio affects stock prices and borrowing costs. A firm's <u>average</u> cost of capital would seem to be a more appropriate cut-off point from the standpoints of operational usefulness and slightly better ease of calculation.

In their discussions of acceptability of projects, the authors make a point that bears repeating: "For unless ... the firm can improve on the rates offered by external investment, it is performing no service to the shareholders which they could not equally perform for themselves and can have no justification for retaining profits." The implication here is that disinvestment (payment of dividends) should be considered along with other uses of corporate funds.

Over-all, the paper is well written. The authors achieved their purpose in showing the superiority of discounted rates of return over return on original investment. They failed to prove, at least to this reader, that IRR per se can serve as a measure of risk.

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REVIEW

A Review of: THE MANY SIDES OF DEPRECIATION
By Leonard E. Morrissey
Tuck Bulletin 23
Amos Tuck School of Business Administration
Dartmouth College

By: Peter Matthews
Staff Associate, Engineering Division
Arthur D. Little, Inc.

Many of the current rash of proposals for stimulating industrial capital investment call for some modification of depreciation policies. Undoubtedly, those not currently familiar with the topic may want a concise exposition of depreciation's economic significance. This pamphlet (which may be obtained by writing the author, Associate Professor of Accounting at Amos Tuck School) can assist those wishing to find the cause of all the fuss. Several problems pertinent to economic stimulation are reviewed. Although only the tax and accounting viewpoint is taken, the material presents many fundamentals of the present-day arguments concerning useful life, cost determination, and cost allocation.

The section on Useful Life briefly defines the term and summarizes the United States Treasury's tax policy. Note is taken of businessmen's complaints that this apparently acceptable policy is disregarded by agents in the field. The difficulty is that these agents force the use of estimates of equipment life as listed in Treasury Bulletin F, and these estimates often unrealistically prolong the tax depreciation period. Two alternative systems proposed for tax handling of useful life, a former Swedish method and that used in Canada, are outlined. The author makes no evaluation of Treasury policy, the complaints regarding its application, or the proposed alternatives.

Tax considerations are again paramount in Professor Morrissey's discussion of cost determination. A number of arguments are mustered for recognizing price-level changes in depreciating assets rather than adhering to actual or original costs. The fact that the American Institute of Certified Public Accountants has rejected these schemes is mentioned parenthetically, without amplification. A variety of methods for countering price-level changes is explained. A questionable conclusion appears here, in the author's remark that the Swedish Plan would eliminate the problem entirely. As he describes it, the Swedish Plan, although it allows a business to establish any rate of depreciation it likes, is based upon original cost and would certainly fail to satisfy those who wish increases in replacement cost recognized. The other

methods described, which do specifically recognize price-level changes, utilize index numbers. The inevitable inaccuracies of index numbers are pointed out as an objection to these methods, but the author hints at approval of the entire concept, by brushing aside this problem as trifling. The major objection noticed is the claim that recognition of inflation here forces the giant step to its recognition in all debtor-creditor relationships. A less staggering but valid objection is overlooked: these methods would favor established businesses over new enterprises by providing tax relief for expenditures made in the past.

The major portion of the pamphlet is devoted to the systems by which depreciation under the Revenue Code may be allocated over an asset's life. Declining-balance and sum-of-the-years'-digits methods are described and their variance from the straight-line method illustrated with tables. Tables are also used to point up the financial benefits accruing to the user through the use of sum-of-the-years'-digits rather than straight-line. A listing of the substantial tax savings realized indicates the impact accelerated depreciation has had on several large corporations. The author observes that such savings do not, however, necessarily result in a proportional increase in capital expenditures. The reasons for this and some objections to accelerated depreciation are discussed in general terms, but are not explored in depth.

One facet of depreciation, the differences found between tax and public reporting, is studied rather thoroughly. Particular emphasis is given to the regulated industries. Professor Morrissey here makes a plea for reporting depreciation publicly, in the same manner as is used for tax purposes.

This suggestion is the only specific stand taken by the author in this pamphlet. His opinion on other matters, however, is sometimes implied by the space allotted. The reader obtains a wide-ranging summary of many stands taken on various aspects of depreciation, but little analysis of the arguments. The material presented is generally too limited to enable the reader himself to perform an adequate analysis. Presumably, the references provided for additional reading would deal with the unanswered questions. In itself, the pamphlet, as a primer, effectively lists and describes the topical arguments on depreciation, and Professor Morrissey's explanation of the true worth of accelerated depreciation is as good as any.

* * *

REVIEW

A Review of: "MATHEMATICAL MODELS IN CAPITAL BUDGETING"
By James C. Hetrick
Harvard Business Review
January-February, 1961, pp. 49-64

By: Frederick S. Hillier, Assistant Professor
Department of Industrial Engineering
Stanford University

A primary contribution of this article, from the reviewer's point of view, is that it should help to promote the use of mathematical models and the philosophy and techniques of operations research, in the areas of long-range planning and capital budgeting. Thus, the article should be of interest to engineering economists, not so much because of its limited, sometimes questionable, sometimes unclear presentation of engineering-economy concepts, but rather because it gives some indication of the ways in which mathematical models and operations-research techniques can contribute to engineering-economy type studies.

Unfortunately, the article suffers somewhat from a lack of conciseness. Many of the author's ideas, although interesting and sometimes ingenious, are neither clear nor convincing, due to the lack of sufficient elaboration and illustration. Thus, the reader who expects much more than a broad conceptual coverage of the subject will be disappointed. Nevertheless, the article still has much to recommend it for the reader seeking a broad-brush treatment of the use of mathematical models in capital budgeting and related fields.

A brief description of a problem considered at length by Hetrick will serve to indicate the nature of the article and its contribution. This example involved a technologically obsolete manufacturing plant. Managerial alternatives included modernizing this plant, or scrapping it and supplying the company's various distribution terminals from plants in adjacent states. Also to be considered was the possibility of increasing the capacity of any of these plants. Various other factors, including a market forecast that the demand pattern would shift considerably during the next ten years, were also involved. In all, including the various combinations of manufacturing and transportation facilities, plus agreements with other manufacturers, there were some hundreds of operating policies to be considered at any given time.

The analysis used in the article is essentially the following. For any assumed management decision as to selection of facilities, the operating problem is that of optimizing

the manufacturing and distribution of products in a system consisting of approximately 200 destinations and 25 origins (plants, terminals, and points of exchange or purchase). This is the well-known transportation problem of operations research and is easily solved by a known algorithm, with the aid of a computer. Thus the procedure is to determine the optimal mode of operation and distribution (which may change as the demand changes) over the foreseeable future, for each practical combination of manufacturing, transportation, and marketing facilities. This, then, determines the optimal operating costs for each alternative over the entire period of study. This information, plus the associated investment schedules, would next be analyzed according to the principles of engineering economy, in order to select the one best alternative. Incidentally, the alternative selected in the example was to modernize the obsolete plant at present capacity and operate it over the entire period of study.

Also included in the article is a very brief description of four other long-range planning problems, where mathematical models have been successfully used. One involves the choice of manufacturing processes, two involve marketing analyses, and the fourth involves an investment portfolio.

To those readers who have already been considerably exposed to the literature of operations research, this article will present little that seems especially new or unusual. However, those engineering economists who have somewhat neglected the new techniques and applications of operations research may gain some insight from the article as to the possible contributions of the new quantitative methods to engineering-economy type analyses.

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BACK ISSUES OF THE ENGINEERING ECONOMIST

A cumulative index of Volumes 1 through 5 is available at 25 cents per copy (this index was published in Vol. 5, No. 4). An index of Volumes 5 & 6 appeared in the Summer 1961 issue (Vol. 6, No. 4).

A complete set of all published volumes may be obtained from University Microfilms, Inc., 313 N. First St., Ann Arbor, Mich. (microfilm or Xerox reproductions).

DESALINIZATION COSTS

According to the American Water Works Association, which represents the public water supply industry, it will be some time before desalted sea water can be considered an economical alternative to fresh water as the source of domestic water supply.

Actual desalting costs at the new Freeport, Texas, plant and other installations are reported to be approximately $1 per 1,000 gallons and up. There have been numerous claims of lower costs for as yet unproved techniques and devices, but the $1 figure is pretty generally accepted as the present goal for desalting. In the current enthusiasm about progress in the field of desalting, supporters have made much of the comparison between $1-per-thousand-gallon desalted water and fresh water at 20 cents to 70 cents per 1,000 gallons. But what they have been comparing is the cost of operating a desalting plant, without taking into account depreciation of the equipment or delivery of the water or the administrative expenses involved in its sale, with the price of public water supply at the tap at the highest unit rate.

The average cost of 1,000 gallons of water to the public water suppliers, as indicated by a recent American Water Works Association survey of 497 utilities in the United States, was 12.3 cents, but this figure included not only the cost of treatment, but that of distribution, depreciation of plant equipment, and administrative costs as well. The cost of treatment for fresh water, including softening, approximates 5 cents per 1,000 gallons. And this is the figure that is comparable with the $1 cost of desalting.

AAAS SYMPOSIUM VOLUME NO. 68

The American Association for the Advancement of Science has recently published a book entitled Sciences in Communist China (Editor: Sidney H. Gould, 872 + XII pages, 23 illustrations; author, subject and geographical index; cloth; June 1961. Price $14.00. AAAS members' cash orders $12.00. Presented at New York AAAS meeting, December 1960.).

This book represents a systematic effort on the part of American scientists, many of them of Chinese origin, to give a clear and unified account of Chinese scientific material gathered during the decade 1950-1960 in various places in the Western world. Emphasis has been placed on the physical and biological sciences and on technology. The chapters on the social sciences are chiefly concerned with the political organization of science in general and with the effect on science of the social and political environment of the country as a whole.

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